Nuclear Economics 2nd Part

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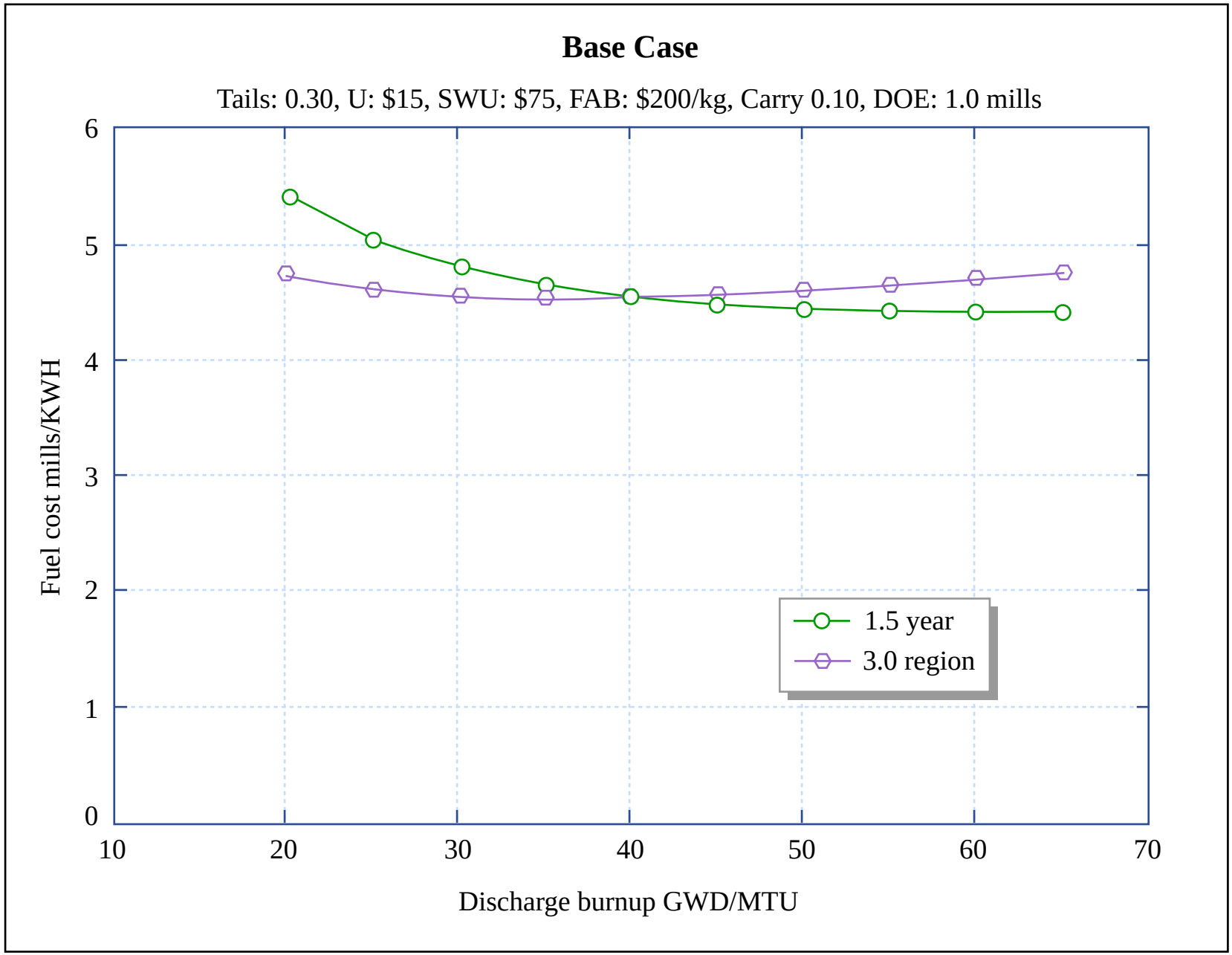
Fuel Cost Rate vs Burnup

- Following slides show fuel cost mill rate and its components vs burnup
- Unit costs are low by today's values



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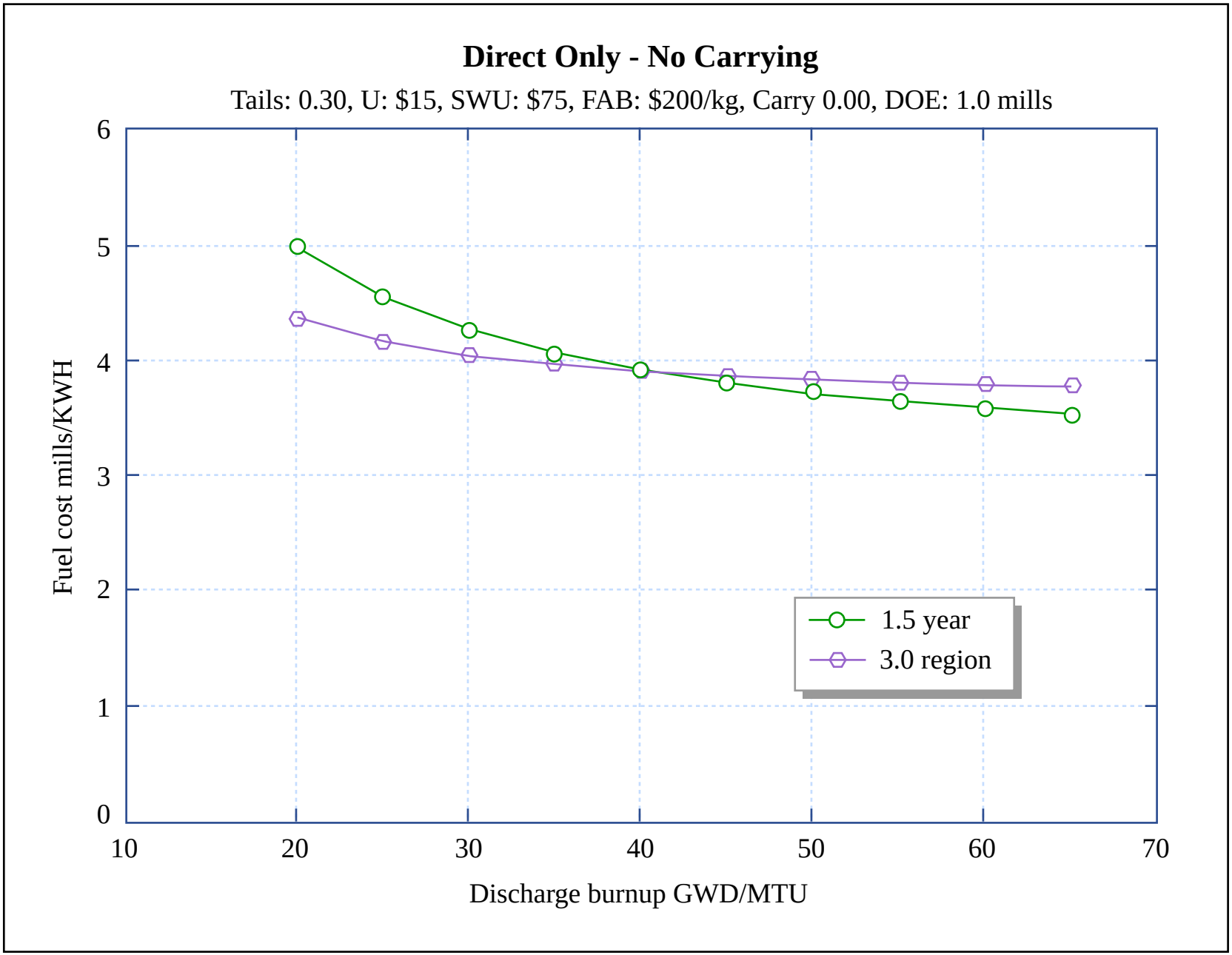
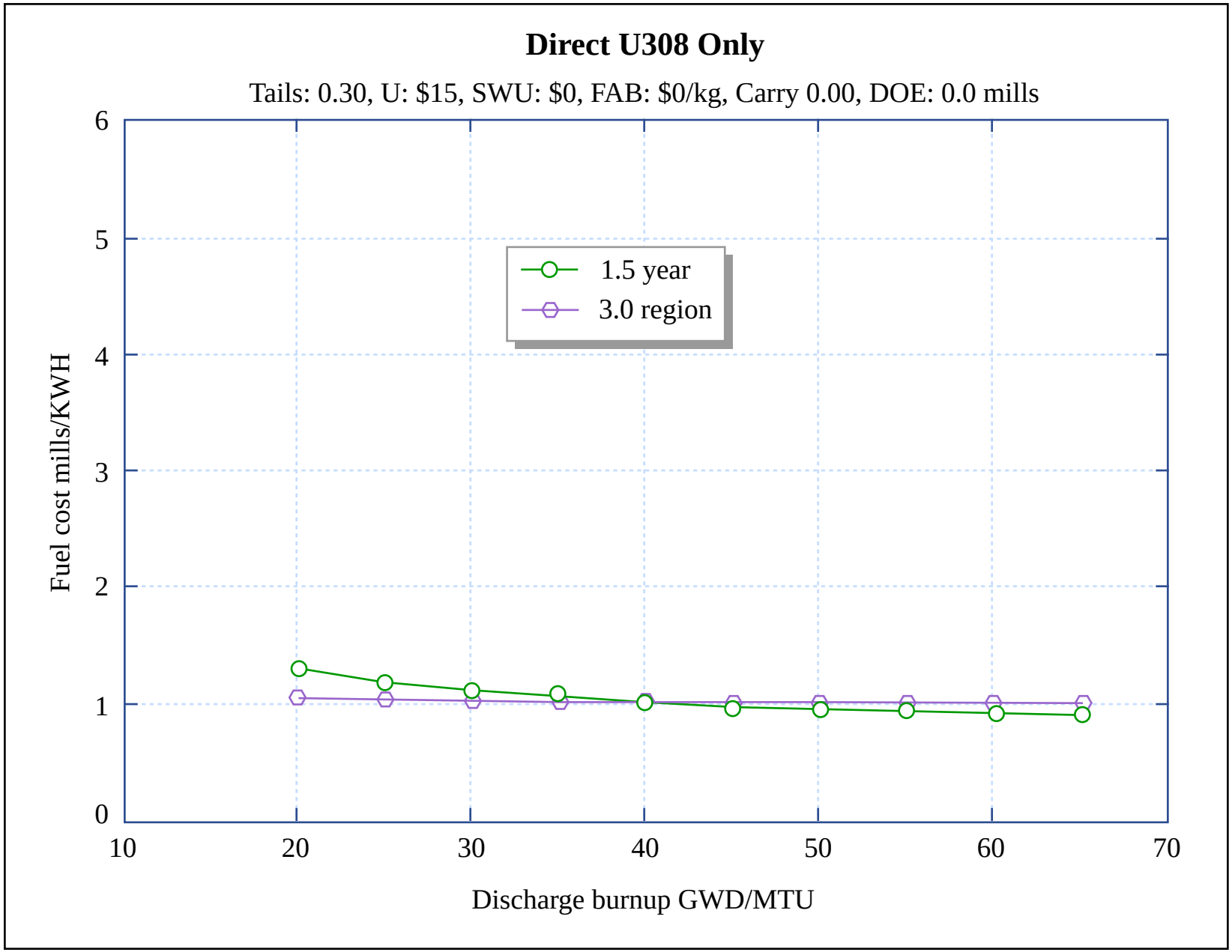
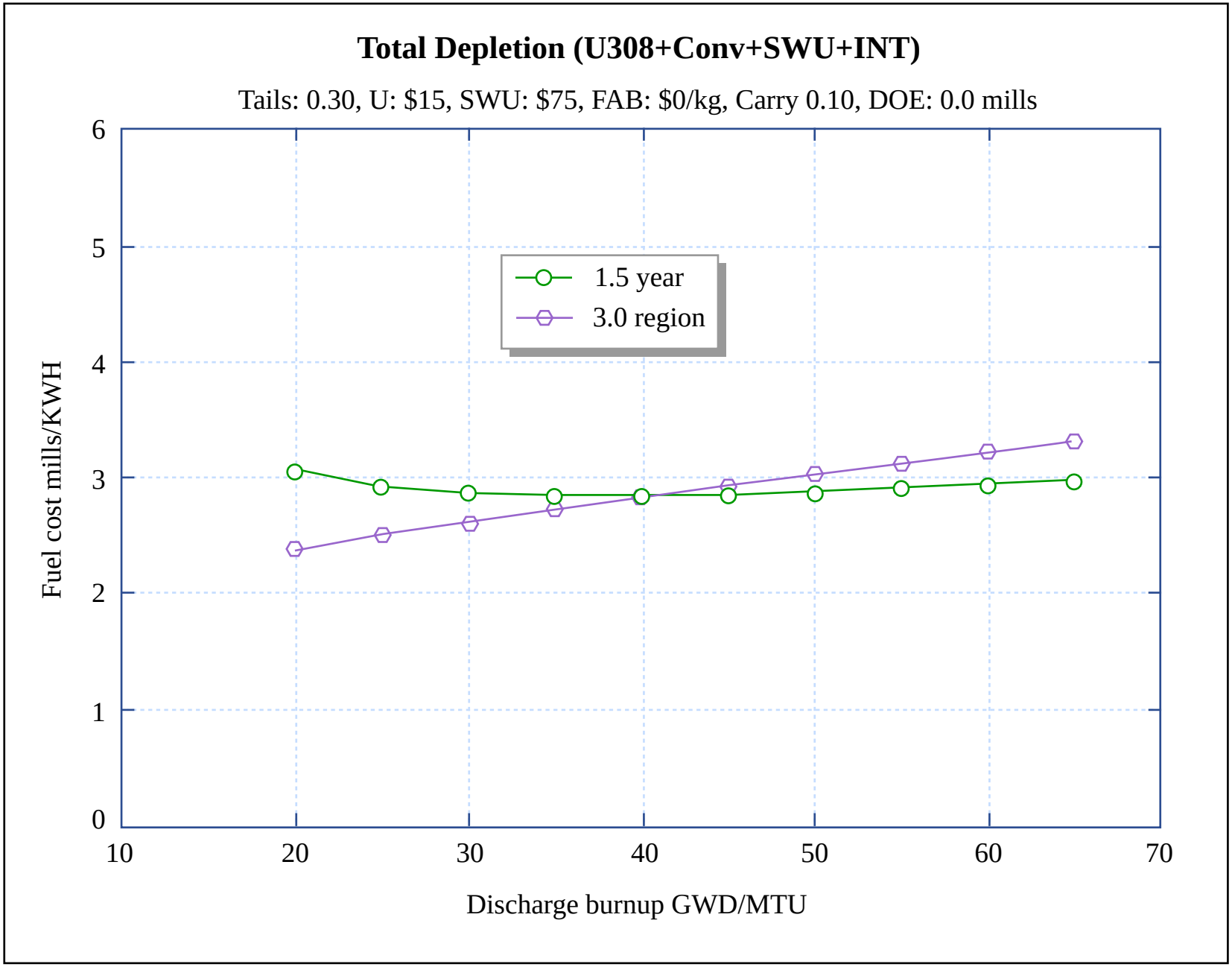
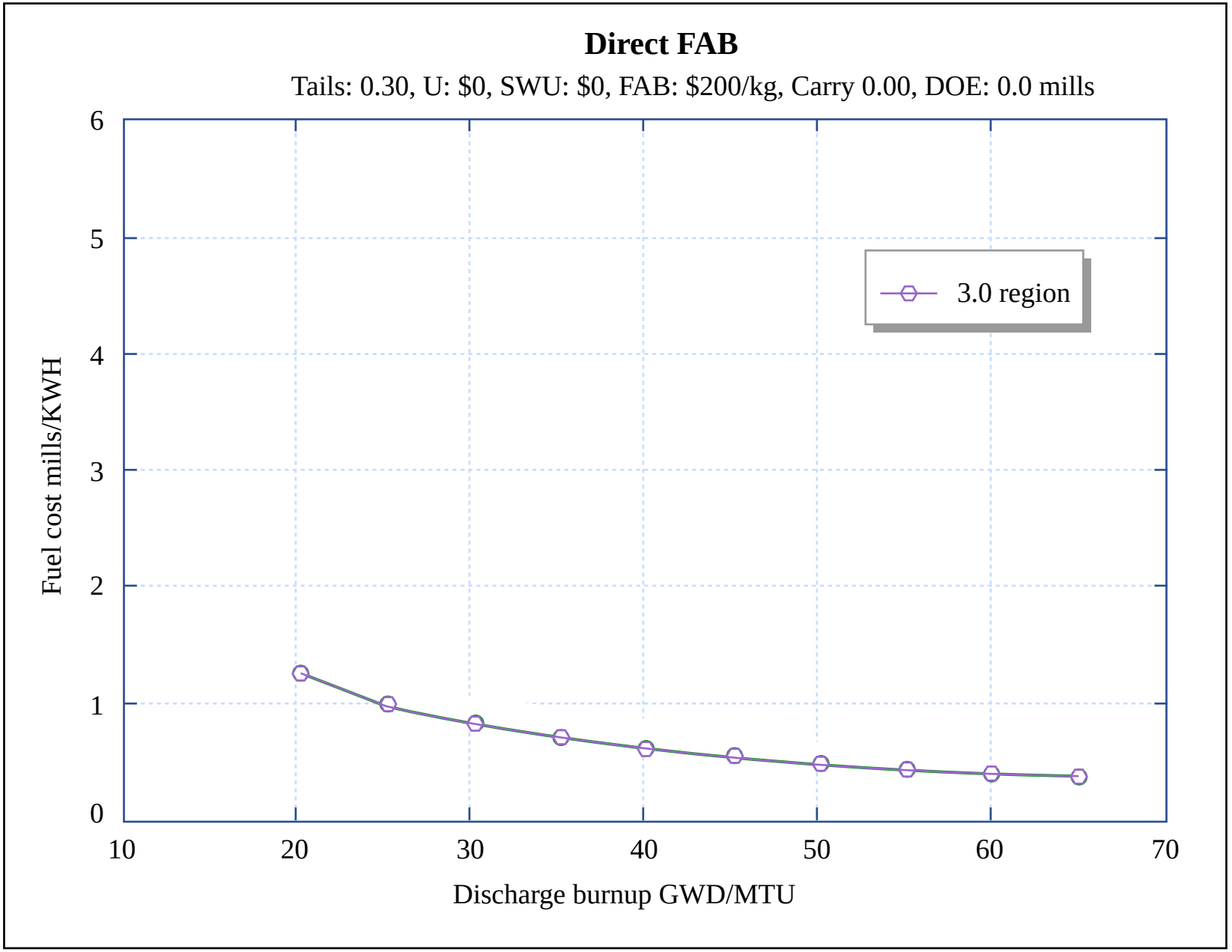
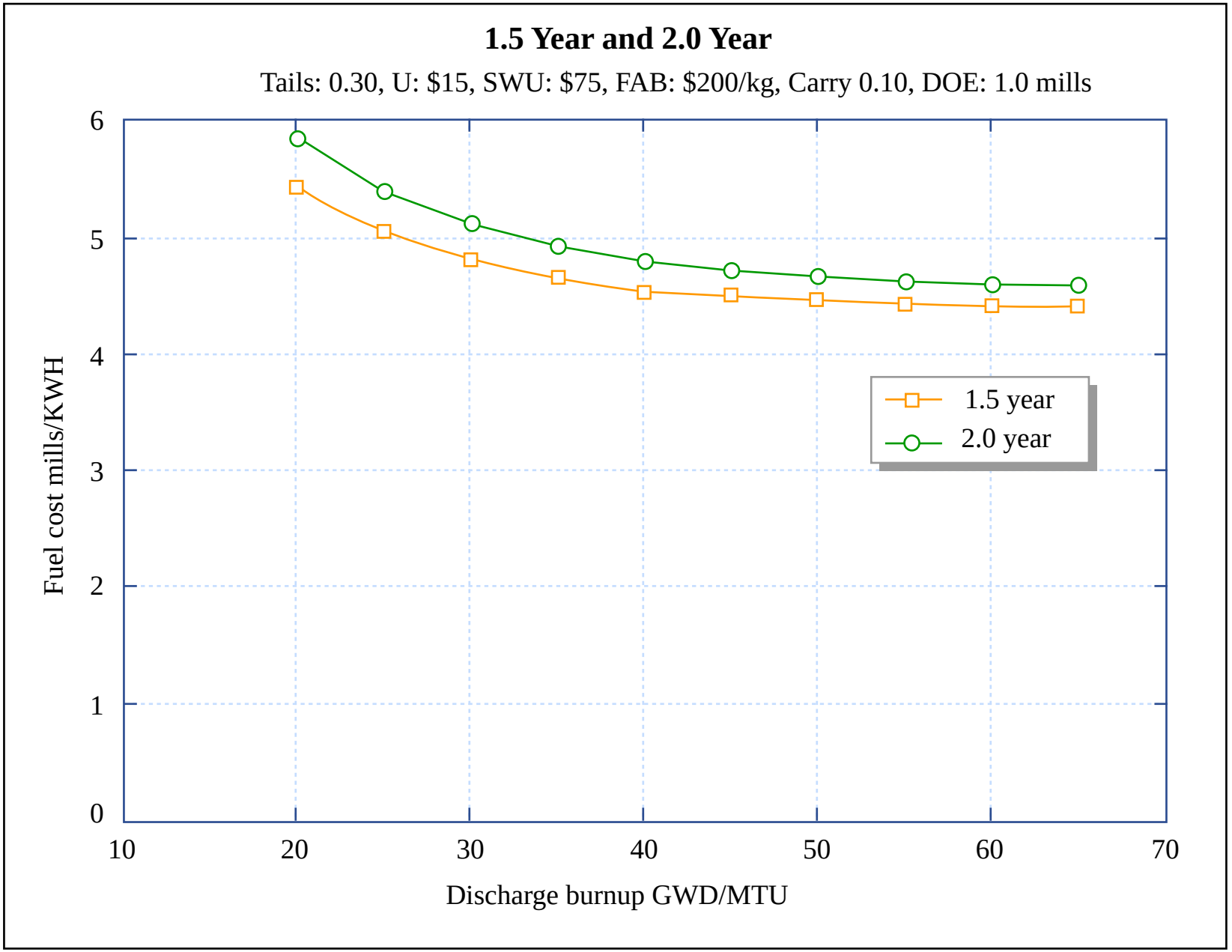
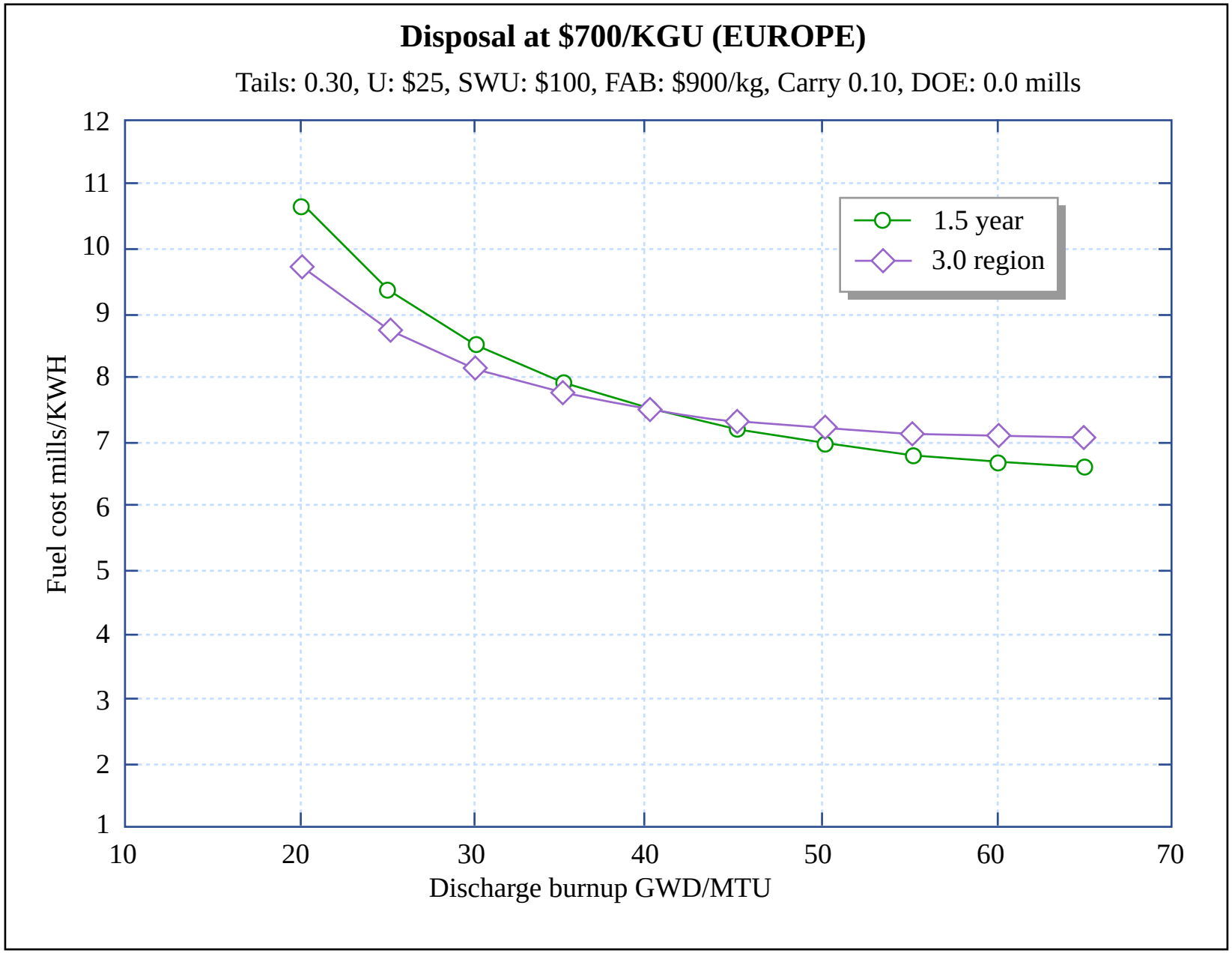




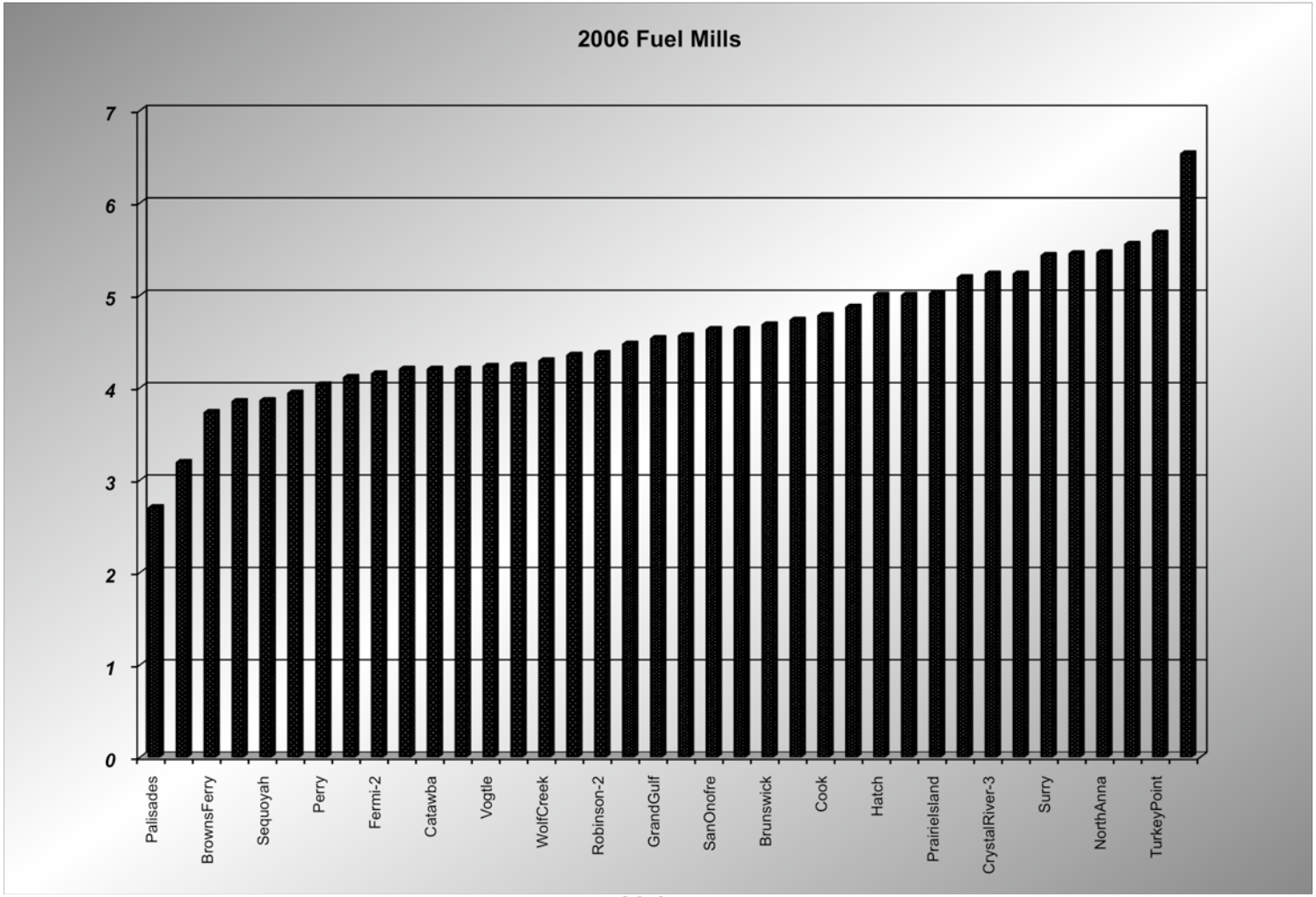








2006 Fuel Costs by Plant



Fuel Contracts Include

- Product purchase
- Terms and conditions
- Options

Terms & Conditions

- Duration of contract
  - Calendar time or reactor cycles
- Amounts to be purchased
  - Absolute or % of requirements
- Notification terms
- Delivery terms
  - What, where, when, what condition it's in
- Warranty

Terms & Conditions 2

- Payment terms
  - Base price
  - Escalation terms
  - Payment dates
    - Calendar or relative
- Who has title, insurance
- Possibility of suspension of work
- Possibility of cancellation

Options

- Change amount, delivery date, enrichment with some lead time
- Change fuel mechanical design
- Change burnable poison
- Have fab vendor perform core design work
- Failed fuel testing

Two Types of Pricing

- Base price escalated
  - Escalation index can be anything (gnp deflator, SIC index, privately published indices for anything)
- Market based
  - Some percentage more or less than published market price of this product
- Both kinds can include floors and ceilings

Payments to US HLW Fund Average ~ $280/kgU

U.S. NUCLEAR REGULATORY COMMISSION

Table 15. Commercial Nuclear Spent Fuel and Payments to the Nuclear Waste Fund by State

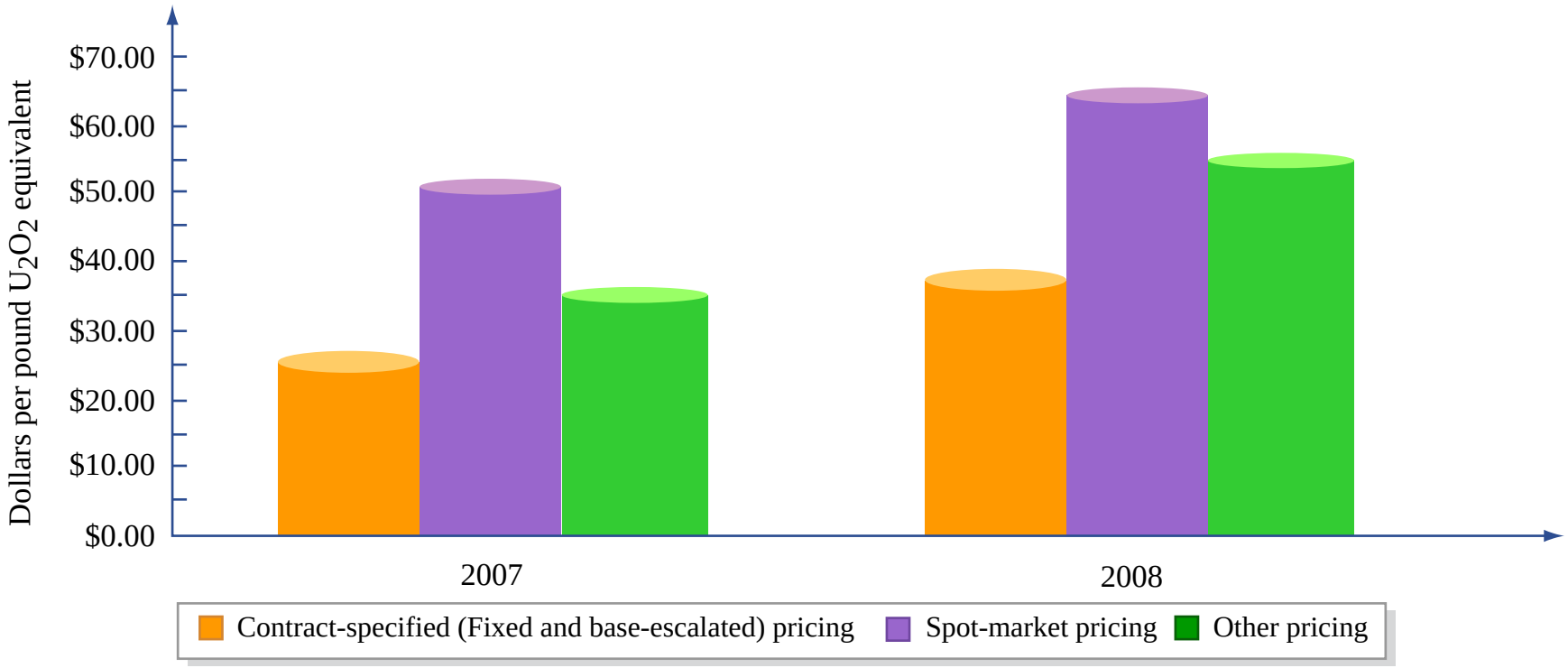
State	Metric Tons of Uranium	Nuclear Waste Fund Contributions ($ M)
Alabama	2,660	719.2
Arizona	1,620	508.7
Arkansas	1,120	285.6
California	2,510	795.7
Colorado	30	0.2
Connecticut	1,830	353.0
Florida	2,660	743.4
Georgia	2,210	662.3
Idaho	90	NA*
Illinois	7,120	1,706.9
Iowa	430	108.7
Kansas	530	180.9
Louisiana	1,010	309.5
Maine	550	65.5
Maryland	1,180	343.5

 Source: NUREG 1350 Vol 22

HLW Payment cont'd

Massachusetts	610	156.8
Michigan	2,280	503.0
Minnesota	1,060	375.9
Mississippi	690	194.0
Missouri	570	187.3
Nebraska	740	252.5
New Hampshire	440	146.3
New Jersey	2,180	574.8
New York	3,130	762.9
North Carolina	3,100	801.7
Ohio	980	287.5
Oregon	350	75.5
Pennsylvania	5,240	1,502.4
South Carolina	3,460	1,197.9
Tennessee	1,280	439.5
Texas	1,660	580.3
Vermont	560	89.8
Virginia	2,180	672.1
Washington	570	152.8
Wisconsin	1,200	344.2
Other	NA	7.6
Total	57,650	16,088.3

There is No Single “Price” for U



Average price for uranium purchased by owners and operators of U.S. civilian nuclear power reactors by pricing mechanisms and delivery year, 2007-2008

Utility Balance Sheet
(Net Nuclear Fuel ~ $85 million/plant)

Consolidated Balance Sheet

U.S. Shareholder-Owned Electric Utilities

($ Millions)	12/31/2008	12/31/2007
PP&E in service, gross	927,412	868,929
Accumulated depreciation	320,294	304,696
Net property in service	*607,118*	*564,233*
Construction work in progress	58,946	47,467
Net nuclear fuel	8,802	7,336
Other property	1,085	2,465
Net property & equipment	*675,951*	*621,502*
Cash & cash equivalents	19,398	14,151
Accounts receivable	44,232	44,091
Inventories	26,865	23,497
Other current assets	59,500	56,281
Total current assets	*149,995*	*138,020*
Total investments	62,671	69,057
Other assets	216,558	200,180
Total Assets	***1,105,175***	***1,028,758***

 Source:EEI 2008 Financial

Capital Cost

$$CC \approx \frac{100(FCR)(UCC)}{8766L}$$

UCC = As built unit capital cost ($per KWe)

FCR = Fixed charge rate

L = Lifetime capacity factor

Capital Cost 2

- Start with an “overnight” cost at project start
- As built cost includes escalation from project start to time of payment for component
- As built cost includes interest during construction (AFUDC) from time of payment to start of operation

Capital Cost 3

- FCR ~ $x / [1 – (1 + x)^{-n}]$
- $x \sim (1 – t)\, b\, r_b + (1\text{-}b) r_s$ = cost of money
- t = income tax rate
- b = bond fraction
- r_b = return on bonds
- r_s = return on stock
- n = book life of plant

Capital Cost 4

- Easier to use spreadsheet
- Today r_s ~ 10.5%
- Today r_b varies from 5 to 15%

How Is Nuke Integrated Into Grid?

- Power cost = capital + production
- Production = O&M + Fuel
- System operators dispatch plants according to cost
- Nukes have high capital costs so like to run at high capacity factor

Production Costs
Fuel is small fraction of nuclear

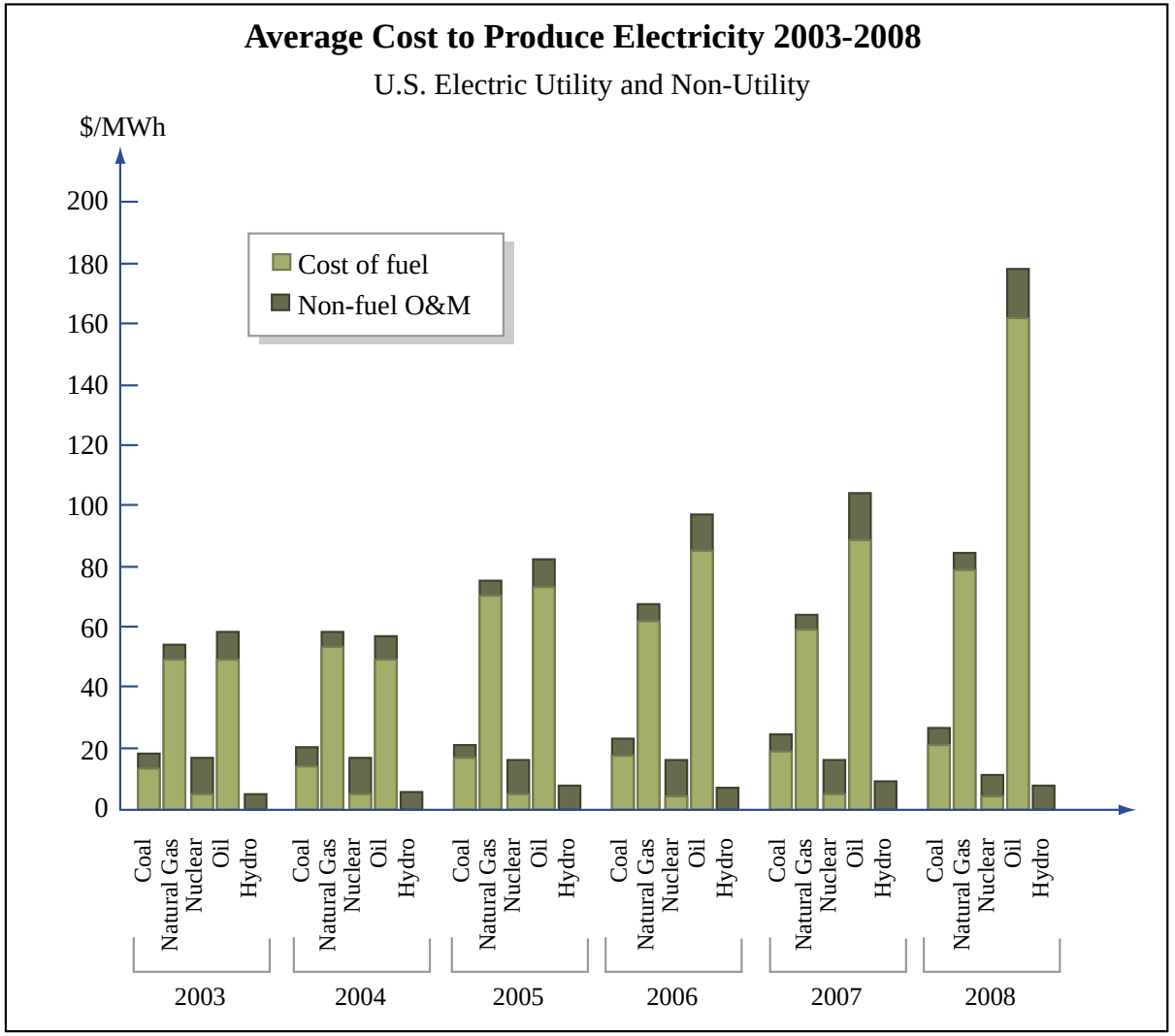
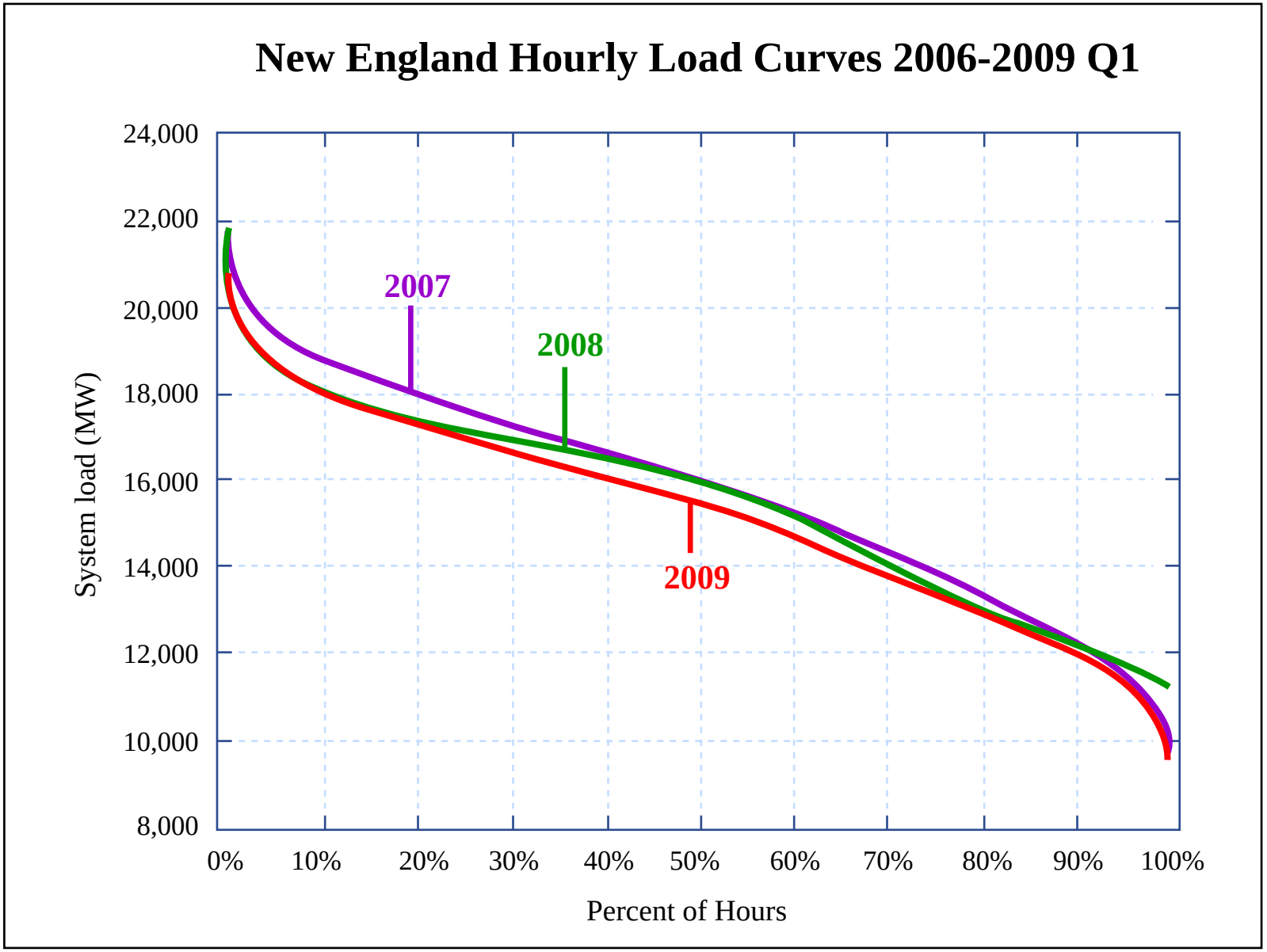


Image by MIT OpenCourseWare.

Source: EEI 2008 Financial Review

“Load-Duration” Curves for New Eng. (50% of time, load > 16,000 MW)



 Source: ISO-NE 2009Q1 Market Rpt

“Price-Duration” Curves for New Eng. 50% of time, price> $40/MWh in 2009

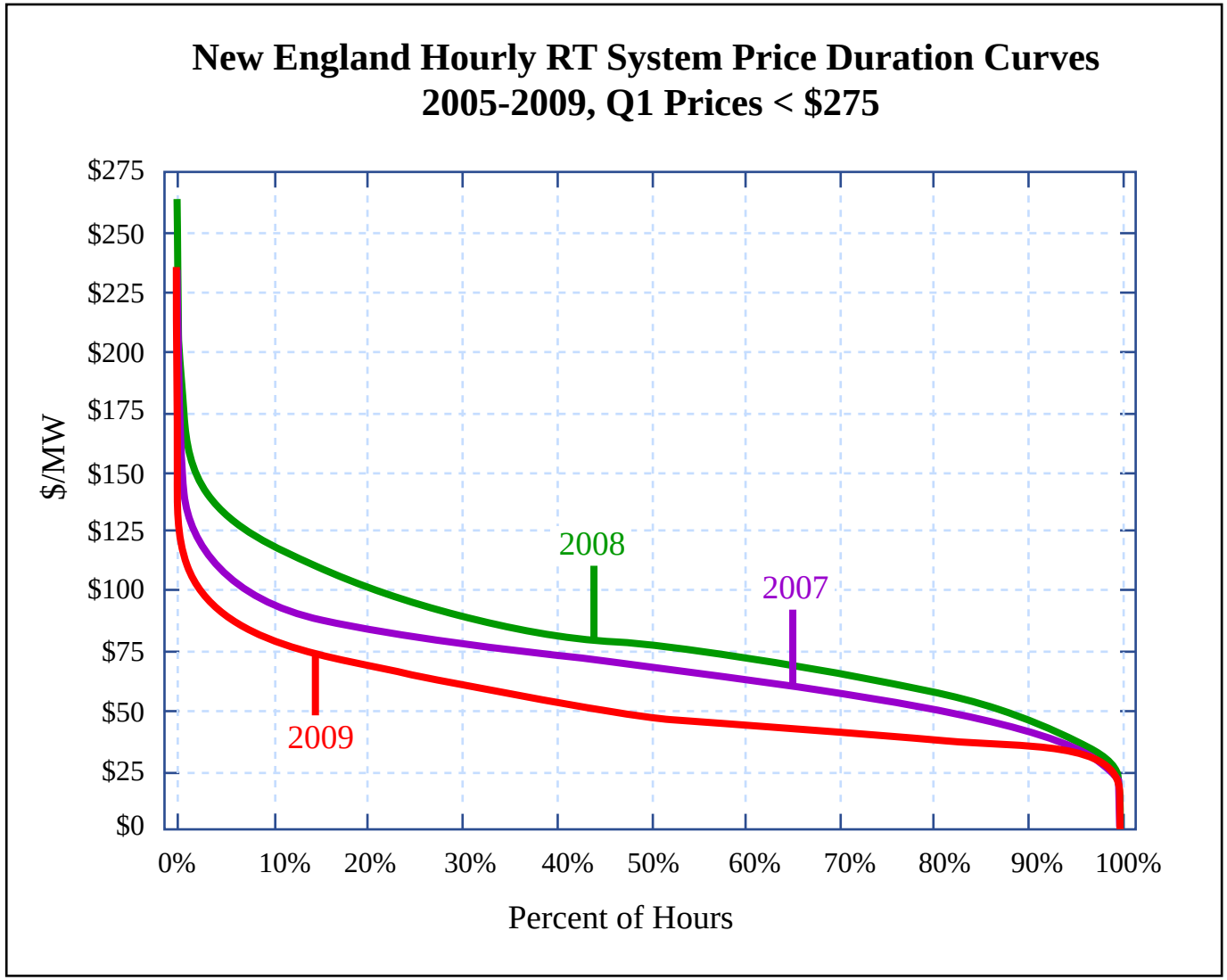


Image by MIT OpenCourseWare.

Source: ISO-NE 2009Q1 Market Rpt

Local Marginal Prices in New Eng.

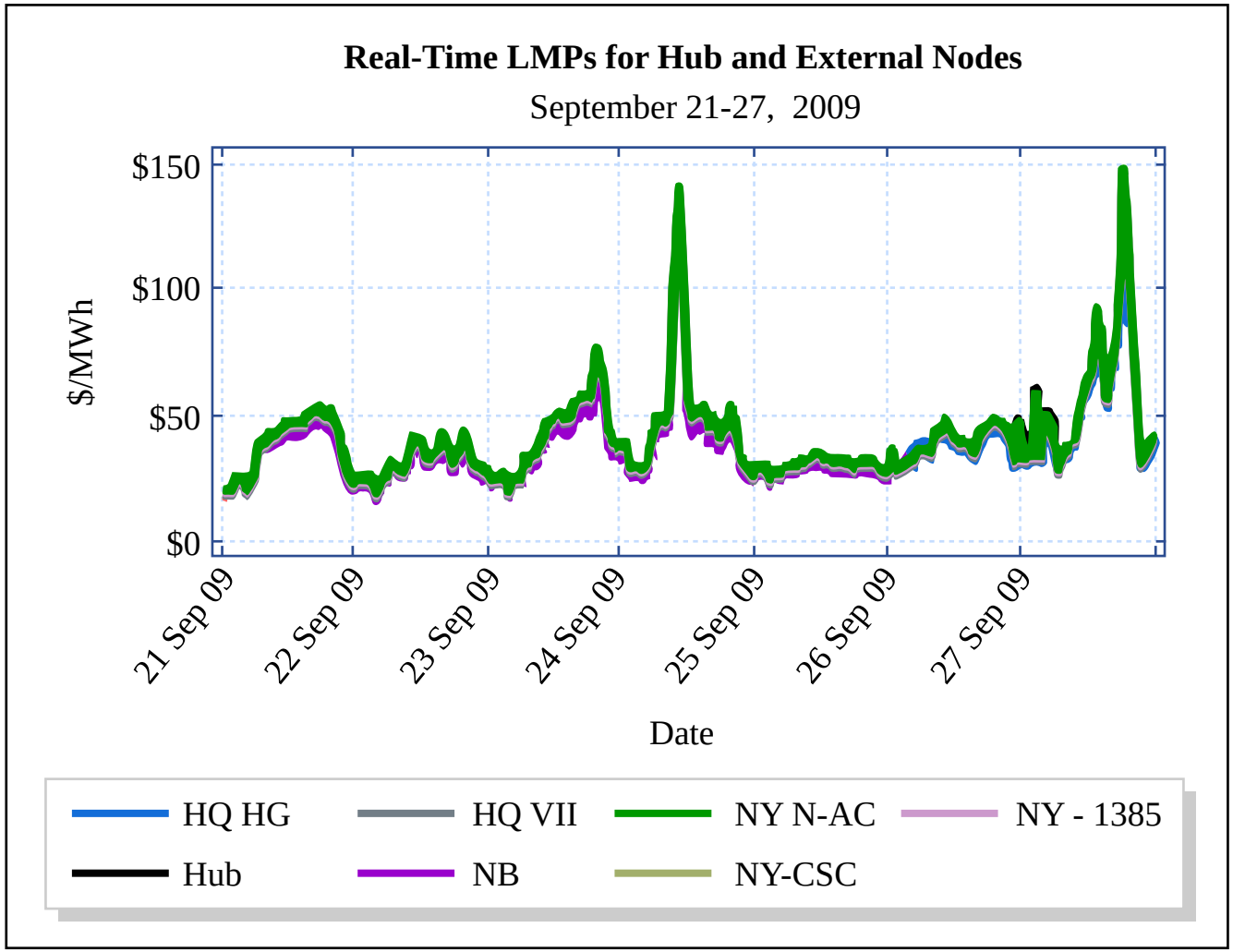


Image by MIT OpenCourseWare.

New England Grid Info

- New England load flows and marginal costs

Daily New England loads:

http://www.cvx.com/java/NELoadGraph.htm

22.251 Systems Analysis of the Nuclear Fuel Cycle

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